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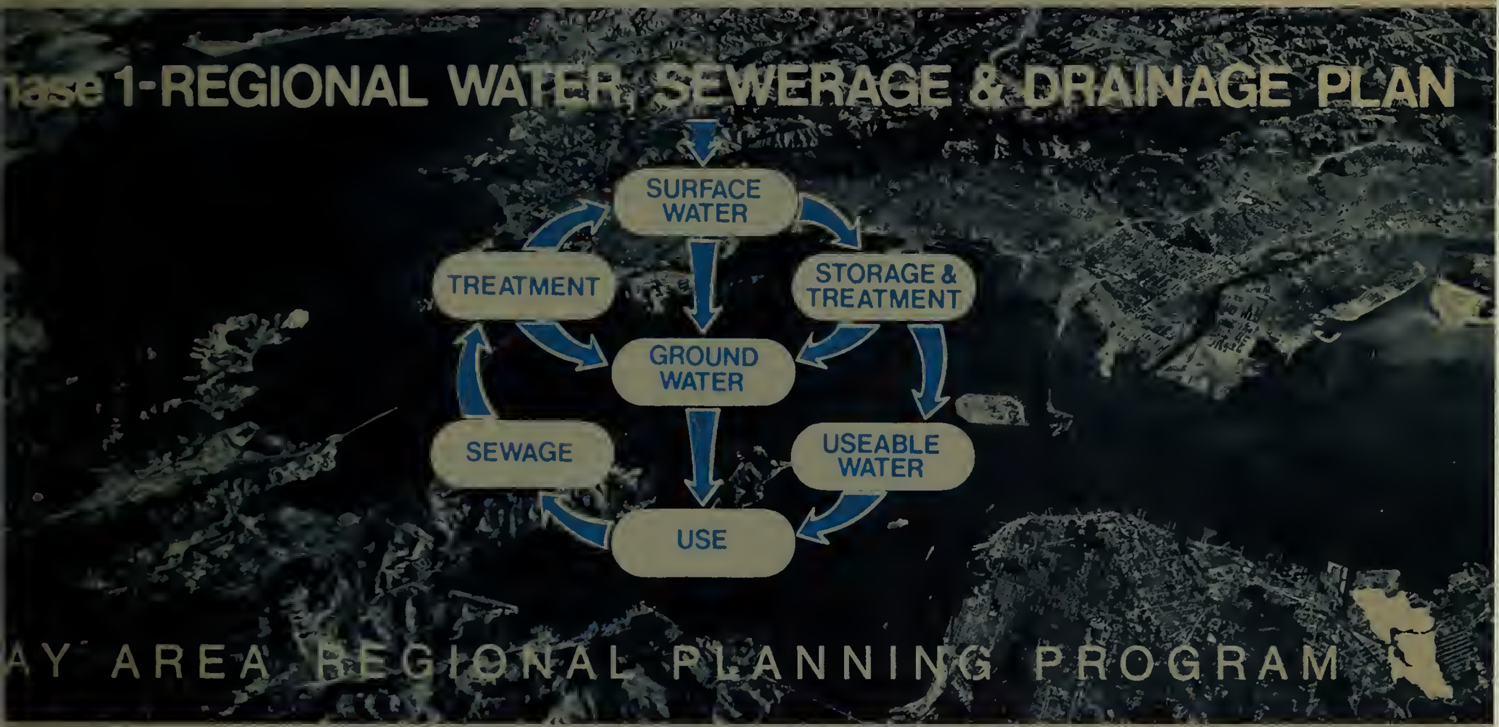

AY AREA REGIONAL PLANNING PROGRAM

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ASSOCIATION OF BAY AREA GOVERNMENTS

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The Association of Bay Area Governments was created in anuary, 1961. It was founded in recognition of the fact that he physical, economic and social well being of the entire egion and of its individual communities requires continuing, reawide cooperation and coordination of policies, plans, and ervices.

he primary function of the Association is to provide the ramework for dealing with regional problems on a cooper-tive, coordinated basis. Although the Association is not itself government agency, it provides the means by which strong, ital units of city and county government work together in lving regional problems and in formulating and implement-g regional development policies.

ormal organization for the Association is provided by con-actual agreement between the member cities and counties ting under the authority of the Joint Exercise of Powers Act the State of California. Present membership includes eight unties and 84 cities representing collectively more than 99 rcent of the total Bay Area population.

he primary objectives of the Association are:

he identification and study of problems, functions and ser-ces in the San Francisco Bay Metropolitan Area and the aking of appropriate policy or action recommendations.

he review of proposals for metropolitan or regional govern-ental agencies and the making of appropriate policy or tion recommendations.

ch other metropolitan or regional functions as are deter-ned by the Association to be appropriate for consideration.

e Association currently is active in the following fields: gional planning, water, sewer and drainage planning, open ace and recreation planning, regional housing policy, crimi-l justice planning, regional information systems, regional port systems planning, and regional economics.

e Regional Planning Program, financed in part by a Federal ban Planning Assistance Grant, is designed to produce a mprehensive regional plan and continuing planning process assist in the growth and development of the region. A l-time planning staff, working in close cooperation with al agencies and other regional units is now completing the gional plan, a general land use plan including open space, idential, commercial and industrial land use patterns as well transportation and institutional uses.

e Association's programs are financed by membership dues d special assessments and by grants in funds and services om other regional agencies and state and federal vernments.

preparation of this report was financed in part through an urban nning grant from the Department of Housing and Urban Develop-, under the provisions of Section 701 of the Housing Act of 1954 mended.

PHASE I
WATER, SEWERAGE, AND DRAINAGE PLAN

Supplemental Report p. 249 7.5

INVENTORY AND STUDY DESIGN

ASSOCIATION OF BAY AREA GOVERNMENTS
CLAREMONT HOTEL, BERKELEY, CALIFORNIA

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FOREWORD

The Association of Bay Area Governments, in February 1964, formally initiated its regional planning program for the San Francisco Bay Area. In addition to preparation of a comprehensive Regional Plan for the Bay Area, several regional studies--including Open Space Element, Ocean Coastline Study, Bay Shoreline, Agricultural Resources, Natural Features, Refuse Disposal, Transportation, Housing, Information Systems, and Water Resources--have been part of the regional planning program.

This is one of a series of study reports prepared by the Association's staff as part of the continuing planning program. It presents the results of a study conducted as the first step in the preparation of a water, sewerage, and drainage plan for the nine county San Francisco Bay Area. Included herein is an inventory and assessment of the current status of water resources planning in the Bay Area and a proposed program designed to develop a recommended regional water resources plan.

Copies of this report are being made available to interested individuals and agencies to provide an understanding of the concepts, proposals, and data being considered by the Association in the preparation of a Water Resources regional plan element.

This report was prepared by Dr. Morgan Johnson P.E. staff consultant to the Association on Water Resources Planning in 1969-1970. Staff assistance was provided by George Swanson, Assistant Planner. The study and report preparation were conducted under the general supervision of James H. Hickey, Planning Director.

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INTRODUCTION

PURPOSE FOR PHASE 1 STUDY

The work presented in this Phase I report was designed to serve as a guideline for a Water, Sewerage, and Drainage Element of the Association's 1970:1990 Regional Plan.

The work of Phase I is designed to (1) review and analyze the existing status of water, sewerage, and drainage practice and planning in the Bay Area, (2) develop policies for further effort in the planning and programming of water resources activities, and (3) to design a program to lead to preparation of a 1970-1990 Water and Sewerage Element and a proposed program for development of future major water, sewerage, and drainage facilities. The actual preparation of the Water and Sewerage Element constitutes Phase II of the program.

SUMMARY OF STUDY OBJECTIVES AND ACCOMPLISHMENTS

One purpose of the Phase I study was to conduct an inventory of the current status of water, sewerage, and drainage planning in the Bay Area. For this reason an examination was made of each agency involved in water resource activities. The inventory study also included a review of current policies and controls, and planning practices. A review of the study findings is presented in Part II of this report.

A second purpose of the Phase I Program was to identify the need for water resources planning development, long range planning goals, and specific objectives to be accomplished as part of the Water and Sewerage Plan Element program.

A third objective was to prepare a program designed to accomplish the recommended objectives presented above. The proposed design is presented in two parts. The first part is a 6-month program to develop a recommended Water, Sewerage and Drainage Plan Element as part of the Association's 1970-1990 Regional Plan.

The second part of the overall program provides for the review of the plan and the development of a long-range program directed toward accomplishment of the approved plan element.

The Phase II Program design is presented in Part IV of this report.

REPORT METHODOLOGY

The three categories of water resources--water supply, sewerage, and drainage--are closely interrelated, and planning in any one cannot be thoroughly accomplished without consideration of the other two fields. Therefore, planning should be done for total water resources management rather than in a more fragmented approach.

However, for the purposes of this report in the light of planning work already completed and the structure of existing districts and agencies the study is divided into these three categories. Close liaison between local, regional and state thinking and planning in water, sewerage, and drainage is essential if a workable plan for 1970-1990 is to be developed.

In addition to a review of existing written reports and plan proposals, agencies at the Federal, State, and special district level involved with water resource activities in the Bay Region were contacted. All flood control agencies and most county public works departments were contacted as well as county planning directors and county health officers.

Contact was made with 88 communities in the nine counties and many cities, including San Francisco, Oakland, and San Jose, were visited in person. Problems and planning were discussed with municipal representatives as well as with many engineering firms.

Engineers or managers of most water districts and sanitary districts were contacted, and attendance at meetings of the voluntary, cooperative, coordinating, sub-regional, county, or regional groups provided exposure to the thinking and planning of many other agencies. The proposed Bay-Delta program was examined in detail because of its current prominence as a proposed solution to the region's sewage disposal problems.

An extensive file of reports and studies, of maps of service areas, and of maps of location of facilities from over 100 sewerage planning agencies, and from a similar number of water distributing agencies, has been established in the Association's Office. Many other reports of State and Federal agencies are also on hand.

CHAPTER I

PHASE I PROGRAM

NEED FOR PLANNING IN WATER RESOURCES

It has been predicted that by 1980 the withdrawals of water for all uses in the United States will equal the recoverable stream flow and ground water supply. It is becoming increasingly evident that our fresh water supply is not an unlimited resource but one which must be preserved, protected, and used to its maximum.

In the San Francisco Bay region in recent years, much attention has been focused on various concepts of water resources. Pumping of Northern California water to Southern California, dams on the rivers, the San Joaquin Drain, pollution of the Bay and the estuaries, floods, decline of the marine habitat, and the Bay-Delta plan for control of waste discharges have all become prominent in the public consciousness.

Yet, there has been no coordinated approach to planning of water resources as a system in the Bay region. The Bay-Delta proposal, resulting from an extensive study by Kaiser Engineers of Oakland, California, covered part of one phase--sewerage. The California Regional Water Quality Control Board regulates quality of waste waters. The local, Federal, and State public health agencies and the fish, game and wildlife agencies recommend water quality standards. The State Department of Water Resources and the Bureau of Reclamation develop projects for water supply. The U.S. Army Corps of Engineers is concerned with navigation and flood control. The Bay Conservation and Development Commission plans for the Bay and the "Shoreline." The Federal Water Quality Administration, the Department of Housing and Urban Development, and many other agencies are involved in one phase of the overall problem. Each is limited by law or administrative regulations as to its area of jurisdiction and interest.

The Association of Bay Area Governments, the recognized regional planning agency, is the only agency with a broad enough program to undertake the problems of water resource systems planning. As the regional agency in the Bay Area designated to review applications for Federal funds and to certify that such plans do (or do not) comply with (1) short range area-wide functional planning, (2) long-range area-wide functional planning, and (3) comprehensive planning for the region, the Association staff has given attention to these fields. However, to fully discharge its responsibility a coordinated plan of a broad regional scope in the area of water resources must be prepared.

With the prospect of the adoption of a broad general plan for waste water control in the region by the State legislature, local communities are in need of regional guidance to aid them not only in their choice between various proposed regional solutions but also in regard to their internal planning for waste water control, water supply, and storm water disposal. Following the adoption of a plan by the State, additional work will still be required to fill the gap between the local planning and the State plan. As the regional planning agency, the Association is in a position to present some long-range objectives for water resources management.

Although the quality of Bay Area waters has been improved, even in the face of increasing population, the probable doubling of population within the next 20-25 years will require increasing attention to higher levels of sewage treatment in order to maintain current levels of water quality. An even greater effort will be needed if water quality is going to be raised to meet desirable levels. The anticipated increase in population also calls for serious attention to water supply and thus for a strong program for water resource conservation.

Not least in importance is the necessity to coordinate and articulate long-range goals in water resources management that will clarify the necessity for concerted action to achieve preservation and improvement of the ecological environment of the Bay Area.

INVENTORY, POLICIES, AND PROGRAM DESIGN

The following description presents in summary form the various elements included in the Phase I Inventory, Policies and Program Design project.

GENERAL

The work of Phase I, spread over a period of eight months, is virtually complete with the printing of this report. Phase I was designed to (1) review and analyze the existing status of water, sewerage, and drainage practice and planning in the Bay Area, (2) develop policies for the continued planning and programming of water resources activities, and (3) to design a program to lead to the preparation of a 1970-1990 Water, Sewerage and Drainage Plan, and a proposed program for development of future major water, sewerage, and drainage facilities.

INVENTORY

A study of the existing situation in water, sewerage, and drainage in the Bay Area from the viewpoint of agencies involved, type of service being offered, organization of effort, results being obtained, policies and controls in existence, and the planning being done was accomplished as part of the Phase 1 Program. The review of results achieved is presented in Section II of this report.

Any plan that is developed must build on the structures already in place and the conditions that exist today. However, in addition to being a workable plan which will provide guidance and leadership to the cities, counties, and districts in the region, the plan must be more than a composite of local plans.

It must be conceived as an enhancement to the environment of the entire region, reflecting regional needs and goals, and yet it must be possible of accomplishment in an orderly fashion by local entities, regional agencies, special districts, and the State and Federal governments.

POLICIES

Development guidelines for water resources planning are presented in Section III. Included in Section III are broad concerns of water resources planning, long-range planning goals, broad objectives of the study, and specific objectives to be accomplished by the overall program.

PROGRAM DESIGN

The proposed program for accomplishing the recommended objectives is presented in two additional phases. One is a program of six months duration intended to develop a recommended 1970-1990 plan and proposed short-range program for effectuation. The next phase of the continuing program includes the revisions of the plan and the development of a long-range program directed toward accomplishment of the adopted plan.

It is understood that planning is necessarily a continuing process and that the plans and programs developed must have flexibility, be subject to change as conditions warrant, and be sensitive to the findings of the continuing planning process.

CHAPTER II

THE EXISTING SITUATION 1969

WATER SUPPLY SOURCES

Water supply for the Bay region originates in a variety of locations and with a number of agencies. The Bureau of Reclamation and the State of California are prime suppliers of water through reclamation and irrigation projects and through the State Water Plan. U.S. Army Corps of Engineers-sponsored projects on watersheds supply water for some sections of the region. Surface water reservoirs of both the East Bay Municipal Utility District and the City of San Francisco supply water for much of the East Bay and Peninsula areas. Locally-developed surface water withdrawals from reservoirs and stream and ground water pumping also make contributions to the total available supply.

Specific water sources are almost innumerable because of hundreds of wells which pump irrigation water as well as domestic and industrial water from ground water reservoirs. However, the sources may be divided into the following broad categories:

Local ground water basins
Local fresh water streams and lakes
Man-made lakes and reservoirs to collect runoff from adjacent watersheds.
Large river basin storage projects
Canals fed by the Sacramento River and San Joaquin River systems
The State Water Plan, providing water through the North Bay Aqueduct and the South Bay Aqueduct
Sierra Mountains storage

Whereas the San Francisco Bay area annually imports about 600,000 acre-feet of water from reservoirs and rivers outside the region, it has been estimated that perhaps 2-1/2 times that much may be needed by 1990. There are some local resources which can be developed but they are a small consideration in terms of the total need. Ground water resources are also not considered significant in the total picture. The one most important ground water basin in the area, located in Santa Clara County, has been overused, to the extent that extensive ground subsidence has occurred. The basin's needs, including replenishment of the ground water, are currently being met with an ever-increasing amount of water from the State Water Plan, imported through the South Bay Aqueduct.

The Santa Clara Flood Control and Water Conservation District, as a corollary to its ground water recharge program, imposes a pumping levy on systems which use the ground water as a source of municipal supply. However, basin-wide programs such as this are not common.

Wholesaling of water to local distributors is a common practice by many county flood control and water conservation districts as well as by the City of San Francisco, and by the Contra Costa County Water District.

The problem of water supply is currently handled largely as an individual local problem or on a sub-regional or special district basis. The size of the sub-region is usually directly related to the size of a particular source of supply. There is no existing over-all regional statement of the problems of water supply and distribution or any proposed solutions on how to solve such problems. Sources of supply for the communities in the Bay region are indicated in Table I in the Appendix. Table I also presents the companies or systems which distribute water to the various communities within the Bay Area.

DISTRIBUTION

There are over 100 public water distributors in the Bay region which have over 200 service connections each. There is a vastly larger number of smaller distributors. Santa Clara County, for example, while listing 19 large distributors, has 237 small distributors. The latter group includes the public supplies serving less than 200 connections as well as the "public premise" group. The "public premise" category embraces the suppliers of potable water which is used for a specific purpose, such as hospitals and factories. At the other extreme in volume of service, the East Bay Municipal Utility District (EBMUD) distributes water to approximately 1,200,000 people in Alameda and Contra Costa counties. San Francisco supplies water for approximately 930,000 people in Alameda, Santa Clara, and San Mateo County as well as distributing water to the 700,000 plus permanent residents of San Francisco.

Water distribution has also been handled largely as a local problem and consequently has resulted in the development of a large number of small water companies. Subregional planning in distribution has been accomplished largely as related to sources of supply and through cooperation of the supplying agencies and the wholesalers. However there have been numerous instances of consolidation or of outright purchase of small companies by larger companies or municipalities; and there are many instances of inter-governmental cooperation, particularly in regards to the connection of mains at the boundaries of service areas or at corporate limits. Such connections allow for mutual assistance in providing pressure, or supply, in times of emergencies and are mutually advantageous in regards to storage.

CURRENT PLANNING

Most, if not all, of the water suppliers and water distributors in the region recognize the need for planning and most are involved in planning within their own service areas in regards to future needs and in seeking, developing, or contracting for sources of supply. Needs are based primarily on local or county projections of population and land use. Planning between agencies has grown as need has dictated, or as has been stimulated by county flood control and conservation districts or other suppliers.

The concern for supply as the demands increase is the most dominant feature in the planning activities with respect to water. Some large distributors and suppliers are contracting, or have contracted, with the state for present and future quantities from the North Bay Aqueduct and the South Bay Aqueduct, and from the San Luis Reservoir. Some are cooperating with other agencies and with the Corps of Engineers in developing water from north-coast river sources. The Bureau of Reclamation is also involved in the planning and development of projects which will provide additional supply. Current or planned projects to develop and bring water to the Bay Region are estimated to provide an adequate supply for the next 20 years.

San Francisco is not only responsible for water supply for its own residents, but supplies water to most of the Peninsula communities as well as some communities in Alameda and Santa Clara Counties. The City has recognized the limitations of its source in the Sierras and is currently studying new sources for additional supply. The Peninsula communities are also cooperatively taking a hard look at alternate sources of supply.

Agencies and industries which draw water directly from rivers or bays, such as in northern Contra Costa County, are faced with diminishing quality of their water supply unless the State Water Quality Control Program is effective in controlling or halting the introduction of untreated or poorly treated water into natural channels. The proposed massive discharge of the San Joaquin drain (see page 13) into the river near Antioch could generate this type of pollution.

A further concern is for ecological imbalance in the estuaries because of intrusion of salt water resulting from reduced flows of fresh water into the rivers and bays. Migration of salt water upstream beyond the current hydraulic barrier maintained at Chipps Island could reduce existing sources of municipal and industrial water. Overpumping of ground water along the ocean and bays and the consequent lowering of the ground water table can lead to intrusion of salt water into the ground water basins, resulting in the permanent pollution of this source of fresh water.

The possibilities of reusing waste waters by subjecting them to additional treatment have been considered, and the City of Burlingame has developed such a project. Use of reclaimed waste waters--domestic sewage, industrial waste waters, and agricultural drainage water which have been rendered satisfactory for re-use by adequate treatment for irrigation, for industrial pusposes, and to some extent for recreation purposes--is becoming recognized. However the general feeling exists that the public is not yet ready to accept the use of reclaimed waste waters in domestic water supplies.

Most communities and water districts are constantly planning expansion or improvements in local facilities to increase the level of reliability and service for existing users and to accomodate an increasing population. The available capacity to serve future population does not appear to be a problem of concern at this time to any major supplier for at least 20 years. It is probable that a future scientific breakthrough in desalinization may help to prevent demand from exceeding supply as has been the case on the eastern seaboard. It is also probable that falling costs of tertiary treatment and rising levels of acceptance of tertiary effluent for reuse will also serve to return water to beneficial uses.

However, in terms of the lead time needed to prepare and effectuate a regional plan for water supply, bringing into consideration all available supplies and sources of fresh water, twenty years is a relatively short period of time, and long-range planning must be started.

SEWERAGE
LOCAL AGENCIES

Sewage collection, treatment, and disposal is handled by many different agencies, in many different ways, and with wide variation in results. Many cities collect and treat their own sewage. Others rely on special districts, which may or may not have boundaries that are coterminous with individual communities. Some special districts serve as collecting agencies but contract for treatment with another district. Table 2 in the Appendix indicates the agencies providing sewage treatment for the Bay region communities.

Some industries discharge their waste waters into municipal or district sewers; others treat their own wastes and discharge it directly into a nearby river or the bay. Seasonal industries, such as canneries, place an extremely heavy load on treatment facilities for short periods of time. Another seasonal problem is rainfall, which increases the total volume of water flowing through the sewage facilities because of the incursion of storm water into sanitary sewers. This wet weather flow may be several times the dry weather flow and consequently the sewage flow volume will far exceed the capacity of the plant. The result is usually a bypassing of raw sewage into the nearest river or bay.

Most cities and districts have virtually eliminated combined sewers. However, San Francisco is the exception. At the present time San Francisco's entire system is a combined sewer system with more than 40 overflow outfalls of untreated combined sewage to the Bay or Ocean in times of storm. The cost of completely replacing the existing combined system with a separate sanitary and storm sewer system is so great that the City has no plans at this time to even propose such a change.

Sonoma County Sanitation District reports great success in sealing lines to eliminate infiltration, and other agencies have had similar success. New sewer construction with new materials promises to reduce the problem to some degree. However, it is generally believed that the biggest source of infiltration is directly related to individual house connections, and therefore almost impossible to eliminate or police.

Two studies of infiltration have been in progress. One, financed by a $165,000 Federal Water Pollution Control Administration grant for the cities of Oakland and Berkeley and for EBMUD, was completed by the Engineering firm of Metcalf and Eddy. The other is a nation-wide study being conducted by the American Public Works Association under the guidance of a committee headed by Paul Soltow, Engineer-Manager of the San Pablo Sanitary District. Results of these programs when available will serve to help quantify the infiltration problem in the Bay region.

Treatment plants, as presently operating or under construction, provide a variety of treatment ranging from simple settlement and sludge digestion of sewerage, through various modified forms, to full conventional secondary treatment or activated sludge. Most plants are, or soon will be, chlorinating the effluent to reduce the disease-causing bacteria which may survive the treatment.

Sewerage planning has been done on a county-wide basis in several of the counties. However, the proposed county-wide plans have not gained wide acceptance among the individual local sanitary districts and/or cities involved. The more successful area-wide plans are those that have been developed on a voluntary basis among adjacent agencies.

The problem of unsewered areas is receiving attention in many of the counties, in some instances with the lead being taken by the county health departments. The general trend is away from individual home sewerage treatment and disposal systems (septic tanks) wherever possible.

CONDITION OF PUBLIC WATERS

There is general agreement that the pollution of regional waters has been markedly reduced as compared with the situation 20 years ago, particularly in terms of coliform organisms and dissolved oxygen. The reduction in pollution was achieved mainly through the quality standards and activities of the Regional Water Quality Control Boards and the cooperation of the waste water dischargers. It is significant to point out that the reversal in pollution trends was accomplished while the area's pollution continued to increase at a rate greater than the rest of the nation.

The problem of floatables (evidences of pollution which float on the water surface) is more noticeable and is currently coming under attack. It is assumed that it will be similarly reduced in the years to come. One immediate need is to develop a means of controlling the discharges of both sewage and solid wastes from the many ships and pleasure boats which use the Bay waters. Some of the military installations in the region are also unregulated.

Measures of pollution which have not been broadly applied are those of toxicants and bio-stimulants. Toxicants are those compounds, which may be found in waste waters which are poisonous or otherwise harmful to life, be it aquatic or human. It might be noted that a level of toxicity which is not harmful for aquatic life is not detrimental to humans. Bio-stimulants are those constituents which stimulate the growth of plants such as algae and which, when uncontrolled, can be unpleasant to humans and can also upset the ecological balance in the waters.

Substantial portions of toxicants and bio-stimulants are not removed by normal primary and secondary treatment of sewage, thus requiring special treatment (tertiary). Tertiary treatment is not commonly practiced in the Bay area. The dispersal factor of receiving waters is counted on, with questionable results, to dilute the contaminants to below the harmful level. The tertiary plant of the community of South Tahoe is being used as an example to illustrate the practicality of advanced treatment.

There are numerous locations about the region where the waters have been posted by the State Department of Public Health as unsuitable for body contact sports, and other locations where the State Department of Fish and Game has noted deteriorating water quality environment, particularly in terms of fish life and shell fish. Increasingly stringent regulations of water quality are, however, gradually resolving the problem.

Areas such as the south end of San Francisco Bay are much less benefited by the flushing action of tides, and the natural dilution of sewage plant effluent is therefore much less effective than in the central Bay where the action of the tides carries it out to sea. This problem has led to proposals to pipe the effluent from the south Bay and from other areas of similar sluggish tidal action to the central or upper Bay for disposal.

Discharge of untreated or only partially treated sewage into ocean waters, by communities and districts on the ocean side of the region, is based on the premise that such a large body of water is able to assimilate the waste by dispersing and diluting the contents of the effluent to the point where they will not be harmful. Destruction of marine life and return of objectionable constituents to the beaches by adverse currents periodically cause trouble with this method of disposal.

PROLIFERATION OF DISCHARGERS

The large number of waste treatment plants and/or waste water dischargers in the region makes the problem of uniformity and control difficult if not impossible to solve. An extremely small plant is not generally as economical nor as efficient as a larger plant. This is not to say that there are not some small plants which operate both effectively and efficiently. It is recognized that many small plants were established as the only reasonable alternative to individual disposal systems (septic tanks) and as such must be considered as a step in the right direction.

Some communities have seen, or are seeing, advantages in combining operations for the treatment of sewage and also to serve other smaller districts in that capacity. This type of cooperation has resulted in improved efficiencies and economies in almost every instance. The cities of San Jose and Santa Clara, which jointly operate a large plant which also serves several independent sanitary districts, provide one example of such a consolidation. Palo Alto, Mountain View, and Los Altos, are cooperating in the construction of a joint plant, as are Redwood City, San Carlos, and Belmont. Stege Sanitary District in Richmond has completed negotiations with East Bay Municipal Utility District whereby it will pipe its sewage to EBMUD while retaining its present plant to provide treatment to wet weather excess. Examples of such joint effort exist throughout the region and more are contemplated.

The particular problem which San Francisco has, that of combined sewers, while it is considered a local problem, is a matter of regional concern because of the obvious pollution of Bay and of coastal water during storm times. San Francisco has no plans to change to a separate sewer system and consequently regional attention is needed to solve this problem. The City is examining methods of handling excess storm flows.

PROGRESS IN TREATMENT

It has been noted that the level of treatment has markedly improved in the Bay Area from practically no treatment 20 years ago to the present level of modified primary or full secondary treatment by most major dischargers. Insistence by the Department of Public Health that all waters be suitable for body contact sports has resulted in recent action by the regional boards requiring year-around chlorination of all effluent. Attempts of the conservationists to preserve the fish and wildlife habitats are also responsible, in part, for increases in the level of treatment. The assertion by many dischargers, that their effluent is of better quality than that of their receiving waters, is true. Continuation and acceleration of such treatment can clean up the waters. The Regional Water Quality Control Boards have performed admirably in raising the overall quality level.

The Porter-Cologne Water Quality Control Act as enacted by the Legislature in 1969 provided the regional boards with additional muscle for enforcing water quality standards. Cease and desist orders may be followed up by bans against further sewer connection, and willful or negligent failure to comply may bring action for a $6,000 per day fine.

Whereas there have been few notable advances applied to the routine treatment of sewage, there are a number of promising innovations in the development or investigation stage, and it is reasonable to presume that methods and results will improve.

Costs of tertiary treatment are difficult to quote because there is little experience in the actual operation of such plants. Costs will vary widely depending upon the nature of the sewage received and upon the particular quality of effluent to be achieved. Again, it is reasonable to assume that techniques will improve and relative costs will drop. The South Tahoe plant previously mentioned is more costly than might be considered necessary because of the decision which was made to pump the effluent entirely out of the basin. Southern California also has had successful programs in reclamation of waste waters through satisfactory treatment, and has a number of other projects in the planning or design stage.

BAY-DELTA PROPOSAL

The single most dominant existing proposal in the water quality control field for a 12-county region including the 9 Bay Area counties is the recently completed "San Francisco Bay-Delta Water Quality Control Program", commonly identified as the Bay-Delta Report. This report, presented to the State Legislature in July 1969, is the result of a multi-million dollar study ordered by the State Legislature in 1965. The study was administered by the State Water Resources Control Board, and largely accomplished by a consortium of consultants headed by Kaiser Engineers.

Program objectives were to make a comprehensive study of the effects of waste and drainage water discharges into the waters of the San Francisco Bay-Delta area and to develop the basic features of a comprehensive plan for the control of water pollution in the area. It was a complex study with many corollary and contributing studies being made by federal, state, and private agencies.

Following a number of public hearings, the report in a modified form was presented to the Legislature with an accompanying report from the board of consultants which served the study in an advisory capacity. The Legislature returned the program to the State Water Resources Control Board with instructions to report back to the Legislature early in the 1971 session with recommendations as to alternate programs and methods of effecting them. Some recommended research studies are also to be carried out during that period. These will include (1) examining the dispersion capabilities of San Francisco Bay, (2) relative toxicity and biostimulation and their treatment, and (3) local studies in Contra Costa and Santa Clara Counties to explore alternative methods of sewage disposal, with emphasis on advanced treatment and on reclamation.

FEATURES:

Findings and recommendations of the final Bay-Delta report by the Kaiser group may be summarized as follows:

1. A regional agency must be formed to insure improved water quality by planning, design, financing, constructing, and control.
2. The recommended water quality control system includes transporting waste materials to the central Bay and eventually to the ocean but later reclaiming and reusing water as possible.
3. The recommended system is designed primarily on the parameters of biostimulation and toxicity, and secondarily on coliforms (evidence of human contamination) and floatables.
4. The first phase of the system calls for completion by 1980 of a system of collectors to convey waste waters to the central Bay for discharge--between the San Rafael Bridge and the Dumbarton Bridge. The second and third phases call for regional treatment, transport to the ocean, and reclamation as possible.
5. A research division should be established by the State Water Resources Control Board for a continuing program of studies and research into biostimulation, toxicity, treatment methods, control of pesticides, model use, and assimilative capacity of regional waters.
6. A project office should be continued until a regional agency can be activated.
7. Financing should be by general obligation bonds, repaid by sale of capacity rights. Operating cost should be charged to users, based on actual use.
8. The state should establish a grant program to aid the overall effort.
9. Agricultural waste waters should be treated as are municipal and industrial wastes.
10. The construction of the Peripheral Canal (a project to convey Sacramento River water southward and to provide some flushing action in the Delta) is recommended
11. Temperature of discharges should be regulated by the Regional Water Quality Control Boards.

OBJECTIONS:

The hearings held at several locations in the Bay Area concerning the Kaiser

The hearings held at several locations in the Bay Area concerning the Kaiser Bay-Delta Report in the spring of 1969 brought forth a number of objections to the plan. These are briefly summarized as follows:

1. The development was based too heavily on toxicity and biostimulation, areas about which not enough is known for long-range expensive projections.
2. The local agencies were not given sufficient consideration either for existing facilities or for needs. There was too little communication between the engineers conducting the study and the personnel at the local county, city and sanitary district level.
3. Little recognition was made of expected improvements in treatment knowledge, techniques, and costs.
4. The proposed plan's objectives could be as adequately accomplished by other alternatives for less cost.
5. As a regional plan, it essentially abandoned the wet-weather flow to the local community by proposing a design capacity of only 1.6 times the dry-weather flow, whereas local experience shows a much greater amount of wet-weather flow.
6. The proposal involves piping untreated sewage too great a distance.
7. Outfall of partially treated sewage to the ocean would be harmful to the ocean environment.
8. Concentration of facilities for treatment

and discharge would lead to chaos in case of breakdown of either plant operation or failure of the line at the point where it crosses the San Andreas Fault.

9. The plan provides no local option and abandons existing plants without compensation to local communities to meet existing long-term bonding commitments.
10. Waste water reclamation appears to be tacked on as an afterthought and involves double-pumping of material.

An additional criticism of the plan is its orientation toward ocean disposal of only partially treated wastes. It is not unreasonable to expect that within the next 20 years discharge to the ocean of any effluent with less than secondary treatment will not be acceptable.

The plan further assumes that water is an expendable resource. It is becoming increasingly apparent that fresh water is a very limited resource and consequently long range planning should be more concerned with conservation than disposal in the ocean. Reclamation and reuse of a substantial portion of waste water, should of necessity, be a part of any future disposal plan. Reclamation would be less expensive if accomplished not too far from its source.

It has become apparent that the deadline for submitting the final report did not allow adequate time to obtain feedback from local agencies and to incorporate such ideas and suggestions in the final draft. Such a process necessarily is time-consuming, but is essential.

STATUS:

Upon completion of the public hearings, the Board of Consultants, which had advised the State Board throughout the program, submitted its report. The Board of Consultants found that the concept developed by Kaiser (for a coordinated system which initially would transport and dispose of suitably treated municipal and industrial wastewaters from the extremities of the estuary to locations near central bay) was sound. They recognized that specific details and location and sizing of the recommended physical facilities must be subject to further planning and feasibility studies by an ensuing regional agency.

Upon consideration of the Kaiser report, the statements made at the public hearings, and the report of the Board of Consultants, the State Water Resources Control Board submitted the following recommendations to the state legislature:

1. The Legislature should adopt at its next session enabling legislation for the creation of a permanent service agency having authority to plan, finance, construct, and operate facilities for interception, treatment, reclamation, and disposal of municipal and industrial wastewaters in the nine Bay Area counties.

2. The Legislature should provide for the continuation of the Bay-Delta Water Quality Control Program on an interim basis until the permanent service agency is created.

3. The Legislature should act now to control long-lived pesticides at their source, regulate their handling, and insure that criteria for their acceptance and use are established by environmental protection experts from resources and health agencies.

4. The Legislature should recognize as a state responsibility, and should provide adequate funding for, completion of urgently needed studies of the toxic

properties of municipal and industrial wastewater, of biostimulating materials in wastewaters that cause undesirable algae growths, and of Bay dispersion capability.

Actions relating to these four recommendations may be summarized briefly as follows:

1. Several bills have been introduced in the 1970 legislature pertaining to Bay-Delta planning. None have been heard by committee as of May 5.
2. The legislature has provided for continuation of the Bay-Delta Program on an interim basis by the State Water Resources Control Board. This has assured additional time for future refinement of the plan. The Board is carrying on additional studies which are described below.
3. Several bills have been enacted on control of pesticides, and additional legislation is being considered this year.
4. Funds have been made available for a significant portion of the urgently needed studies.

At the present time the State Water Resources Control Board has executed research contracts for study of Bay dispersion capability and of toxicity and biostimulation. In January, the State Board contracted with the Contra Costa Water Agency to undertake a cooperative study of treatment, reclamation and disposal of municipal and industrial wastewater. This study, which is a continuation of Bay-Delta work, will be able to evaluate the needs of the waste dischargers and thus provide guidance to them and to the regulatory agencies. The Board has selected a consultant to undertake the 15-month study. Dischargers in the South Bay (identified in the Bay-Delta report as an area having critical water quality problems at this time) are in the process of joining together to undertake a similar cooperative study with the State Board.

The State Water Resources Control Board has formed a water quality advisory group for the Bay Area. The Group, which is composed of representatives of waste discharger organizations and consulting engineers, has been organized primarily to review all ongoing State Board research and planning studies having potential impact on the Bay, including cooperative studies with local agencies. ABAG staff members participate in all meetings of the group.

This period allows time for input from other studies, such as the Firebaugh Program, and from other agencies (including ABAG) which may have contributions to make to the planning of regional waste disposal facilities. The Firebaugh Program is a project of three federal and state agencies to determine the feasibility of removing nutrients (bio-stimulants) from agricultural drainage waste waters.

Federal and state agencies who were to some degree responsible for various phases of the Bay-Delta plan and/or invested sums of money in it have some pride of ownership or authorship and have tended to accept at least the general concepts. The San Francisco Bay Regional Water Quality Control Board in May of 1969 agreed to "use the general concepts of Phase I of the plan recommended by the Final Bay-Delta Program Report as guidelines in reviewing applications for grants...". The same concepts have underlain later regulatory acts of the board.

On the other hand many counties, cities, sanitary districts, and industries have reservations concerning the plan in its present form. Any plan to be successful must have support at all levels of government.

Therefore, although it is highly probable that the Legislature will adopt some version or some portions of the Bay-Delta plan and assign it to an agency to administer, it is reasonable to expect that the plan will be considerably modified before that time. The degree of modification may well depend upon the ability of the agencies concerned to present and support their recommendations.

Strong efforts should be made to accomplish such proposals within six months so that such information will be considered when the State Board reports to the Legislature early in the 1971 session.

DRAINAGE ORGANIZATIONS

Seven of the nine Bay Area counties have formally established county flood control and water conservation districts. The district in San Mateo omits the water conservation function from its title, and in San Francisco the public works office handles drainage problems on a city (county)-wide basis. Some of the districts were formed primarily to handle imported domestic water, others have limited their functioning solely to flood control. Some districts are active in both functions.

In most counties the county board of supervisors also serves as the flood control district board, but zones of need are established with an individual board for each zone. The engineering and administration is commonly performed within the county public works department. The district in Santa Clara, however, is virtually independent of other county administration. Some counties have handled problems only on a project basis as need arose; others have performed on a county-wide concept, planning and collecting data and anticipating specific problems.

Flood control improvements have been largely confined to channel improvements and relatively less work has been done in retention. Some counties improve the channels--accepting responsibility for handling storm waters on that level--and leave to the local communities the concern of conveying water to the channels. Other counties perform whatever storm design and construction is accomplished, except for the handling of drainage which is incidental to street construction.

Many water projects have been proposed, studied, and in some instances built, through the cooperation of the Corps of Engineers. The Corps has issued a number of reports. One, published in preliminary form in 1967, is titled "Appendix II - Flood Control - to the Report of Survey on San Francisco Bay and Tributaries."

Local communities, as a general rule, accept responsibility for handling of storm waters within their jurisdictions and conveying it to flood control channels. Storm sewers are common in the newer urban communities while many suburban localities rely largely on gutter and ditch conveyance.

The subject of drainage should also include agricultural drainage, although little attention has been paid to this problem. The proposal for a San Joaquin drain, to collect agricultural drainage water from western San Joaquin Valley and discharge it untreated into the San Joaquin River near Antioch, has caused considerable concern about the resulting effect on the water quality of the estuaries because of the dissolved salt and biostimulant contents of the discharged water. Construction of the lower end of the drain has been deferred pending extensive research studies on the feasibility of treating the agricultural waters to eliminate this problem.

In spite of the fact that eight of the nine counties in the region have formed flood control districts there is a wide disparity in their operations and functions. Because of political boundaries, organization on a watershed basis has been somewhat limited. Most agencies are dependent upon federal funds, either Corps of Engineers or Soil Conservation Service, and to a less extent HUD grants, for projects of any magnitude.

CURRENT PLANNING

Although the county flood control districts are variously engaged in collecting hydrologic data, planning zones of flood control, and establishing planning programs, there have been very few reports prepared on a county-wide basis. A number of communities have prepared separate local drainage plans.

Prior to the current Association activity, the only broad approach to storm and flood water planning has been some studies by the Corps of Engineers. The Soil Conservation Service is engaged in flood control planning of projects on a watershed basis, in cooperation with local interests.

While storm drainage and flood control are primarily watershed-oriented problems, with relationships between the flood control district and the local agencies to be worked out, it still remains that the flood waters discharge into regional waters and as such the concerns become region-wide in their application.

Down-stream effects of floods and the pollution effects of flood waters are definitely a regional concern and need to be attacked on a regional basis. The basic concept, that the storm waters are a natural resource and should be used where possible rather than passing them down stream as rapidly as possible is also of extreme regional significance.

Included herein (Fig. I) is a print of a watershed map developed by the Association as a part of this study. The map was prepared as a base for drainage planning and has already been used in determining the boundaries of the Association's subregional planning study areas.

INVOLVED AGENCIES

In addition to counties, municipalities, flood control districts, sanitary districts, water districts, and other utility districts, there is also a diversity of regional, state, and federal agencies involved in the water resources problems of the Bay region. These are organizations which can provide input for a regional study and are groups with which coordination is necessary. These agencies are among the many which have been consulted in evaluating the current activity and proposed planning and programs for Bay region water resources.

REGIONAL

The Association of Bay Area Governments in its continuing program of regional planning has provided much basic background information which will provide information and background for a study of water resources. These studies include:

Preliminary Regional Plan
Population Studies and Projections
Land Use Studies and Planning
Base maps, including Topography
Regional Geology
Ocean Coastline Studies

Solid Wastes Disposal Review
Sub-Regional Study Areas
Regional Plan 1970-1990.

In addition to the Association, there are several other area-wide agencies whose concerns are closely related to those discussed in this study. Four of these are regional water quality control boards. A fifth is the San Francisco Bay Conservation and Development Commission.

The latter agency was commissioned to develop a plan for San Francisco Bay and in the process made a multiplicity of special studies on such topics as: Flood Control, Geology, Water Pollution, Public Utilities, Fish and Wildlife, and Ecology. However, all of these are related only to the Bay proper. This agency was given new life and its responsibilities were further defined by the 1969 session of the State Legislature. It is broadly concerned with control of the San Francisco Bay shoreline, with control of fill, and with control of development of a strip 100 feet inland from a defined shoreline.

The regional water quality control boards, as established by the state, are primarily responsible for control of quality of waste discharges into the waters of their respective regions. The immediate Bay watershed and some of the adjacent coastal areas are under the jurisdiction of the San Francisco Bay Regional Water Quality Control Board with offices in Oakland. Parts of Solano, Contra Costa, Napa, and Alameda Counties adjacent to the Delta region are in the region of the Central Valley Regional Quality Control Board in Sacramento. The coastal watershed of Sonoma County and part of Marin County are in the North Coast Region at Santa Rosa; and a portion of southern Santa Clara County as well as southern San Mateo are included in the Central Coast Region at San Luis Obispo. These regional boards, acting upon recommendations from the State Department of Fish and Game and the State Department of Public Health, as well as on other judgments of quality, establish waste water quality control regulations and enforce compliance by the dischargers. Recent action by the legislature in making possible a $6,000-per day penalty for certain violations and providing for restriction of building permits has given the boards additional power. The regional water quality control boards carry on a monitoring and enforcement program to continually upgrade existing quality standards in the face of a growing population and an expanding economy.

Other agencies, both state and federal, are organized on regional, district, or area categories, but with these groups the subdivisions are strictly organizational or administrative. The regional quality control boards, while subject to the general guidance of the State Water Resources Control Board, are quite autonomous in their functioning.

STATE

Statewide agencies having particular concern with the waters of the Bay region include the Department of Public Health, the Department of Water Resources, the State Water Resources Control Board, the Department of Fish and Game, the State Reclamation Board, and the Division of Soil Conservation. A newly formed state agency, the Interagency Council for Ocean Resources (ICOR) is beginning a study of the ocean front environment.

FEDERAL

A number of federal agencies are directly and highly involved in the problems of water resources in the Bay region. These include the Federal Water Pollution Control

Administration (FWPCA) of the Department of Interior, the Bureau of Reclamation of the Department of Interior, the Corps of Engineers of the Department of Defense, the Public Health Service of the Department of Health, Education and Welfare, the Geological Survey (USGS) of the Department of Interior, the Soil Conservation Service (SCS) of the Department of Agriculture, and the Department of Housing and Urban Development (HUD).

Many of these agencies are participating in planning, designing, and construction of projects in water conservation, water supply, and water control, either alone or in cooperation with local and/or state agencies. Others provide outright grants for various phases of water resources planning and construction.

OTHER GROUPS

A number of cooperative, coordinating groups have been established in the Bay Area and have served their participants as clearing houses, as vehicles of cooperative action, and as mediums of exchange of information. These include such groups as the Alameda County Sewerage Advisory Committee, the North Bay Water Advisory Council, the Bay Counties Water Problems Committee, the South Bay Sewerage Advisory Committee, San Francisco Bay Area Water Users Association, the San Mateo County Water Quality Advisory Committee, and the Managers' Committee of the California Sanitary and Sanitation Districts Association.

In many counties the public works directors and/or city engineers meet on a regular basis to discuss flood control and drainage problems. There was some attempt to organize county contact or advisory committees in each of the counties as a part of the Bay-Delta study. This framework is still being used in some of the counties.

REQUIREMENTS OF THE DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT

As a further service to governmental agencies in the Bay area, it is expedient to develop functional (facilities) plans in the water resources fields of (1) water supply and distribution,(2) sewerage collection, treatment and disposal, and (3) drainage and flood control.

The Association is the only agency with responsibility for comprehensive planning and consequently is the one agency which is in the position to do this type of coordinated water resources systems planning. All other agencies are limited in their functions to only some fragment of the total need.

The Department of Housing and Urban Development (HUD) as a grantor of federal funds for the planning, design, and construction of water resource facilities has established a set of requirements which must be complied with in order for agencies to be eligible for such grants. These requirements are quite specific and are summarized in the following paragraphs in terms of water and sewer functional planning.

1. Purpose: An area-wide planning certification process is specified to establish eligibility for grants for water/sewer facilities.
2. Provisions:
   a. There must exist adequate long-range comprehensive planning for the area.
   b. There must exist adequate long-range functional planning for the area.

c. There must exist an adequate short-range plan for the functional system.
d. The facility to be assisted must conform to b and c above.

3. Certification: Effective October 1, 1970, no HUD grant for water/sewer facilities shall be made unless the following have been separately certified:
   a. Planning area and organization
   b. Comprehensive planning
   c. Functional planning and programming (any project must be consistent with this plan and program).
4. Planning achievement by the Area Planning Organization (APO)
   a. Three elements of comprehensive planning must have been accomplished.
      (1) Work program for at least 12 months
      (2) Adoption of statement of areawide goals and objectives
      (3) Adoption of areawide land use element
   b. Two additional activities must be accomplished and must be subject to continual refinement and improvement:
      (1) Functional planning
      (2) Functional programming
5. Guidelines for areawide water/sewer planning and programming
   a. Develop integrated water/sewer/drainage plan and program
   b. Coordinate with state, regional, and local agencies
   c. The APO should:
      (1) Be the responsible agency for water/sewer planning and programming.
      (2) Develop plans for areawide systems to provide adequate capacity.
      (3) Provide for health and safety protection in plans and programs.
      (4) Prepare plans and programs for flood management.
      (5) Enlist participation of concerned state, local, and industrial groups.
      (6) Involve public official and citizen participation in process.

6. Areawide water/sewer plan element. Initial certification will be on basis of preliminary water/sewer element of comprehensive plan which must include:
   a. Statement of its relationship to areawide goals, objectives, and land use element of comprehensive plan.
   b. Delineation and description of various service areas.
   c. The type and location of major facilities.
   d. An allocation of responsibilities for carrying out the water/sewer plan and related program.
   e. Provision for citizen participation.
7. Areawide water/sewer program. The APO must adopt a preliminary short-range (5-10 years) water/sewer program which must include:
   a. Major facilities needed to carry out the plan.
   b. A schedule of priorities of needed improvements and general cost estimates, arranged in accordance with one or more of the following:
      (1) A consecutive rating system.
      (2) The estimated year of need of each project.
      (3) Specified sub-areas.
   c. Provision for citizen participation.
8. Guidelines for water/sewer facilities plan element and program.
   a. The APO is the responsible agency.
   b. Areawide systems with adequate capacity to serve future needs.
   c. Systems to protect health and safety of residents.

d. Flood hazards and flood plain management.

e. Participation of all governmental and private organizations concerned with water/sewer.

f. Public official and citizen participation in the planning process. (Required for re-certification)

9. Recertification. Recertification after the first year will be based on evidence of continual progress.

The Association of Bay Area Governments as the designated Regional Planning Agency in the Bay Area must comply with these requirements. The future of all agencies in the nine-county region who wish to avail themselves of HUD water or sewer grants, depends on the Association's success in developing the required planning program.

CHAPTER III

PROPOSED REGIONAL PLANNING CONSIDERATIONS

FUNCTIONAL PLANNING CONCERNS

History shows that the nation has overestimated what originally appeared to be the unlimited quantity of natural resources. The nation's supply of fresh water was considered to be inexhaustible, including fresh water lakes, streams, and underground supplies. It was thought that air was unlimited, free for the taking and using. We are learning that our supplies of air and water and other resources are not unlimited.

Today we are tempted to make the same assumptions about the ocean. We can continue to create another pollution problem, or we can plan to conserve the resource of fresh water and, in the process, not add to the pollution of the ocean. Just as it eventually became necessary for the federal government to move into the pollution control field in interstate waters because the problem was out of hand, so it is probable that in time an international agency will be necessary to control the pollution of international waters.

Counties, agencies, municipalities, and special districts throughout the Bay region have accomplished a vast amount of planning for water supply and distribution, sewage collection and treatment, and flood control and storm drainage on an individual or subregional basis. However, there is no study which has devoted itself to the overall concept of water resources in the nine-county region. A number of reasons for such a study were presented in the introduction, but the basic underlying need is for total water resources systems planning on a regional basis. Such planning could be accomplished in part on a watershed basis, but the problems of water supply cannot be confined to such boundaries. Since watersheds also drain into common regional bodies of water, a regional approach to planning is clearly needed.

The boundaries of such a region cannot be limited to county boundaries, or by nine county boundaries, because water is transported long distances and because San Francisco Bay receives surface water from an area that represents 2/3 of the State of California. However, such limits must be utilized to effect the planning and its implementation.

The approach must be a total systems approach because water supply can not be studied without considering waste water reclamation and flood waters; sewage disposal cannot be planned without considering wet weather flows and water quality; flood control cannot be truly evaluated without thinking of its use in water supply and in recreation, and without considering its possible effects on pollution. Combined use of many water resource facilities must be seriously examined in any broad program of water use and conservation.

LONG-RANGE PLANNING GOALS

Certain long-range goals are proposed which are based on the premise that (1) water is a natural resource in the public domain, (2) each user has a responsibility to return the water it uses in the most useable condition, (3) waste water may not be dumped in an untreated condition into public waters, (4) fresh water is too valuable and too scarce to be wasted. These principles should apply to agricultural waste waters as well as to municipal and industrial waste waters. The recommended long-range goals are as follows:

1. Water is a limited natural resource in the Bay area and therefore must be preserved.
2. Specifically, adequately-treated water is needed in the Delta, in the bays, in the rivers, and in other estuaries.
3. Treated (and untreated) sewage should not be transported to sea and lost for possible reuse until other alternatives have been thoroughly explored.
4. The offshore areas of the ocean must also be recognized and treated as a valuable and limited resource of the Bay region. There are already strong objections to discharging partially treated wastes in these areas. This trend will intensify.
5. Waste water can be treated; it can be made usable and therefore it should be kept as close as possible to the location of its origin, where it is needed.
6. Long-range plans should first be directed toward the concept of local or sub-regional treatment and disposal or reuse, rather than toward ocean disposal and permanent loss.

BROAD STUDY OBJECTIVES

Several study objectives should be accomplished by a study such as the one proposed. They include:

1. Examine water supply and distribution, sewerage collection, treatment and disposal, and storm drainage and flood control in the light of a total water resources system concept.
2. Establish the need for the planning of water resources management to preserve, and enhance the environment of the Bay Area.
3. Establish the concept of conserving water resources rather than wasting them.
4. Examine the question of local vs regional responsibility for the planning and costs of various phases of water resources management.

SPECIFIC OBJECTIVE

The specific objective of the program will be to develop a plan and program for water resources systems management. The program will be expected to:

1. Establish long range goals for water resources management.
2. Develop a plan focused on the total picture of water resources and to maximize their conservation.
3. Provide regional planning in the specific fields of (a) water supply and distribution, (b) sewerage collection, treatment and disposal, and (c) storm drainage and flood control on an interrelated systems basis.
4. Directly involve local agencies in the planning process, both directly and in county or sub-regional association.
5. Provide a plan to which the local community and district can relate on an immediate and continuing basis.
6. Propose a plan which will provide guidance to the local municipalities and districts in their own planning.
7. Provide a program for the facilities and action needed to begin the effectuation of the plan.

GENERAL APPROACH

Once the above goals and objectives are adopted, the problem becomes one of determining the specifics of the long-range plan and then how best to plan the transition from the present situation to the eventual objective.

It should be recognized that the local agencies have a vast investment in treatment facilities, an investment which involves pride of accomplishment as well as effort and long term financial commitments. It should also be recognized at the outset that mere bigness does not necessarily insure quality or economy, but only size. It is frequently assumed that quantity and economy are directly related but this assumption must not simply be taken for granted.

Strong attention should be given to a sewerage program which (1) evolves from the local situation as it exists, (2) combines treatment on a sub-regional (possibly watershed) basis where it can be shown to be feasible, (3) treats the wastes to an acceptable level, (4) and either discharges locally, or reuses, as the case may develop. Treatment for re-sale could be performed at any level where the market would make it feasible. Many alternative approaches to this basic concept can be considered, and it is quite possible that different methods will apply better to different sub-regions.

CHAPTER IV

THE CONTINUING PROGRAM

PROGRAM CONCEPTS

It is recommended that a Water, Sewerage, and Drainage Facilities Plan be accomplished based on the broad concept that water is a natural resource, that it must be used as efficiently and totally as possible, and that it needs to be retained where it can be of the most benefit.

The study should consider the inter-related problems of all phases of water management and should be developed in reasonably close communication with local agencies. It should consider water resources as a total system, but must necessarily develop segments of the plan to fit the individual needs in water, sewerage, and drainage.

The plan can reasonably be accomplished in three phases. The first phase, to provide for an inventory of the existing situation, to develop policies, and to present a program design, is covered in this report.

The second phase, resulting in a recommended 1970-1990 Water, Sewerage, and Drainage Plan, must necessarily be compressed in time to meet the requirements of the HUD deadline date. In view of the limited time available additional work will be needed.

Therefore, the third phase will allow time to revise and refine the plan and to extend the programming to a longer period (10-20 years).

A description of Phase II and III of the total program follows.

PHASE II- 1970-1990 Water Resources Plan and Program - Estimated Cost $61,000.

General

A six-months program is recommended to accomplish development of a 1970-1990 plan for water resources in the three categories of (1) water supply and distribution, (2) sewerage collection, treatment, and discharge, and (3) drainage and flood control.

It is expedient that a plan and program be developed as rapidly as possible as a service to the entire area. It is also to be expected that a recommended plan, prepared in Phase II, will of necessity undergo revisions and refinements on a continuing basis as other controlling factors and additional data unfold.

Studies made and conslusions reached in the program should be available for input into the recommendations with respect to a regional program for water pollution control which the State Water Resources Control Board must make to the Legislature in January 1971. Such conclusions may provide alternatives to other proposals, such as the Bay-Delta Plan, and therefore, it is important that they be formulated and presented in time to be effective.

There are also a number of reasons why the Phase II program should not be expected to develop a final plan. One factor is the probability that the Legislature will adopt a broad plan for water pollution control during the 1971 session of the legislature, so that a plan completed before that time will have to be revised as much as necessary when the state plan's concepts and controls are superimposed on local and regional programs.

A recommended plan, developed during Phase II effort should be in part based on communications with local agencies. Whereas, the plan should reflect sound regional planning concepts, it must recognize the local situations as they exist and be aware of the problems which local agencies would encounter in fitting their future programming to the recommended regional plan. The short-term program will not provide adequate time to receive feedback from the local agencies on reactions to a proposed plan and to incorporate changes that appear warranted.

A number of studies, which are planned or are under way by other groups will provide additional information which can be drawn upon for the revised plan. Results of some of these studies may not be available in less than a year's time.

The program leading to a first draft plan would examine the problem, assess the conditions, provide broad guides to alternative planning for water resources, develop sub-regions, stimulate local cooperative planning, establish concepts, objectives, and principles of management of water resources in the region, and suggest a tentative short-term (five years) program of activity.

Specific Items to be Accomplished

1. Adapt the watershed map to sub-regional planning areas.
2. Map existing sewage collection and treatment service areas and facilities.
3. Map existing water supply and distribution service areas and facilities.
4. Map flood control and drainage facilities and areas.
5. Project population and land use and needs in water supply and distribution, sewerage collection and treatment and disposal, and control and treatment of storm waters.
6. Adopt objectives and broad planning guides for long-range water resources management.
7. Involve local agencies and groups in the planning process.
8. Develop a recommended plan as a guide to long-range objectives to be achieved, and suggest feasible alternate methods of reaching such objectives.
9. Present a short-term (five years) program to begin to effectuate the proposed plan.
10. Provide recommendations of further planning and programming.

Specific Areas for Consideration

Many specific items of concern need to be examined and evaluated in the light of regional concepts of planning and programming water resources management. Those should include the following:

1. Water Distribution
    - a. Advantages of consolidation operations of distributing agencies.
    - b. Reasons for regional control in addition to quality.
    - c. Interconnecting systems.
    - d. Level of service.
2. Water Supply
    - a. Adequacy of sources of supply.
    - b. Possibility of increased use of surface waters.
    - c. Desirability of a regional wholesaling agency.

   - d. Payment for right to extract water from ground or surface sources.
   - e. The diminishing ground water and methods of recharge.
   - f. Quality of water required for recharge
   - g. Effect of the By-Pass Canal.
3. Reclaimed Water
   - a. Use of reclaimed water for industry and agriculture.
   - b. Other potential uses.
   - c. Possibilities of closed systems -- water to sewage to water, etc.
   - d. Required level of quality for various uses, including ground water recharge.
   - e. Reuse of waste water for domestic purposes.
   - f. Effect of percolation on pollutants.
4. Cost Distribution
   - a. Equitable distribution of costs of clean water between sewage treatment and water treatment.
   - b. Benefits of accidental location, adjacent to source of water and to a convenient receiving body for treated wastes.
5. Present Facilities
   - a. Present condition of treatment facilities.
   - b. Adaptability of present facilities to revised or expanded treatment.
   - c. Maximum use of present facilities in program of transition to ultimate system.
6. Priorities
   - a. Relative importance of various levels of purity in environmental waters when compared to other public needs.
   - b. Importance of body-contact water sports in all public waters.
   - c. Importance of ecological balance.
   - d. Importance of shell-fishing industry.
7. Random Dischargers
   - a. Pollution contributed by ships, etc.
   - b. Necessity and means for controlling.
8. Individual Home Treatment Systems
   - a. Prevalence and problems
   - b. Programs to eliminate problems.
9. Sub-Regional Treatment
   - a. Desirability as against regional treatment.
   - b. Advantages over local treatment.
   - c. Possibility of local primary and secondary treatment and sub-regional tertiary treatment.
10. Relative Costs of Treatment
   - a. Cost vs plant size curve to determine optimum conditions.
   - b. Comparison of transporting costs vs treatment costs.
   - c. Increased cost of treatment of "old" sewage.
   - d. Relative costs of treatment for progressively better effluent.
11. Toxicity and Bio-Stimulation
   - a. Effect on ecology and on humans.
   - b. Technique of treatment and resulting costs.
   - c. Possibilities of future progress in treatment.
   - d. Potential uses for partially treated waters.
12. Agricultural Drainage
   - a. Volume and quality of drainage waters.
   - b. Possibilities of treatment and level required.
   - c. Effect on receiving waters.
   - d. The San Joaquin Drain.
13. Wet Weather Flow
   - a. Amount of wet weather sewage flow.
   - b. Methods of reducing quantity.
   - c. Feasibility of storing overflow for later treatment.
   - d. Polluting effects of storm run-off.
   - e. Other methods of treating excess waters.
   - f. Separation of sanitary and storm sewers.

14. Flood Waters
   - a. Upland retention vs improved channels.
   - b. Retention of waters rather than wasting.
   - c. Combined use of floodways and recreation.
   - d. Use of flood water to recharge the ground water supply.
   - e. Erosion prevention.

Phase III - Continuing Program Estimated Cost $42,000

General

Continuation of the project is recognized as essential for the implementation of the 1970-1990 plan. Hearings will be held; local agencies will have an opportunity to review and react to the plan; other concerned organizations will desire to express their views. These reactions will be considered in the revisions of the plan, always recognizing the responsibility of the Association to maintain a regional view.

Results of other studies, not previously available may provide additional knowledge which should be applied to the former decisions. Pertinent action by the State Legislature and the Water Resources Control Board as well as other governmental agencies may in effect require reconsideration of some suggestions of the first draft plan.

The provision for an additional twelve month program would make it possible to further develop and refine the plan. The broad principles would be applied more specifically to the existing situation, results of further studies would be incorporated, sub-regional planning could be further developed with local groups, costs could be evaluated, necessary adjustments to the State program could be made, and a medium-range (10-20)years) program of accomplishment could be presented.

Specific Items to be Accomplished

1. Refine and adopt plan as required to develop a final plan considering feedback from all agencies and research program.
2. Modify plan if necessary to provide means of meeting stated objectives of such regional plan as may be adopted by the Legislature.
3. Apply knowledge gained from other new studies to indicated revision in the planning and programming.
4. Present a final plan for approval and adoption, recognizing that a continuing program of planning and programming to greater detail will need to be performed by some regional agency.
5. Present a medium range program (10 to 20 years) to schedule necessary improvements.
6. Suggest methods for continuing planning and revised programming as changes occur.

CHAPTER V

APPENDIX

TABLE 1

UTILITIES FURNISHING WATER SERVICE TO COMMUNITIES

(Water, Sewerage, Drainage Survey, Association of Bay Area Governments - Sept. 1969)

COMMUNITY	MUNICIPAL WATER	
	DISTRIBUTED BY	SUPPLIED BY
Alameda County		
Alameda	East Bay MUD	Mokelumne River
Albany	East Bay MUD	Mokelumne River
Berkeley	East Bay MUD	Mokelumne River
Emeryville	East Bay MUD	Mokelumne River
Fremont	Ala. Co. Wat. Dist.	Surface
		San Francisco*
	Citizens Util.	Surface
Hayward	City of Hayward	San Francisco
Livermore	Cal. Wat. Serv.	Ala. Co. FCWCD*
	City of Livermore	Ala. Co. FCWCD
Newark	Ala. Co. Wat. Dist.	Surface
		San Francisco
Oakland	East Bay MUD	Mokelumne River
Piedmont	East Bay MUD	Mokelumne River
Pleasanton	City of Pleasanton	Wells
San Leandro	East Bay MUD	Mokelumne River
Union City	Ala. Co. Wat. Dist.	Surface
		San Francisco
	Citizens Utilities	San Francisco
Contra Costa County		
Antioch	City of Antioch	Co. Co. Co. Wat. Dist.*
		San Joaquin River
Brentwood	City of Brentwood	Wells
Clayton	Co. Co. Co. Wat. Dist.	Co. Co. Co. Wat. Dist.
El Cerrito	East Bay MUD	Mokelumne River
Hercules	East Bay MUD	Mokelumne River
Lafayette	East Bay MUD	Mokelumne River

COMMUNITY	MUNICIPAL WATER	
	DISTRIBUTED BY	SUPPLIED BY
Martinez	City of Martinez	Mokelumne River
Pinole	East Bay MUD	Co. Co. Co. Wat. Dist.
Pittsburg	City of Pittsburg	Mokelumne River
Pleasant Hill	Co. Co. Co. Wat. Dist.	Co. Co. Co. Wat. Dist.
	East Bay MUD	Co. Co. Co. Wat. Dist.
	City of Pleasant Hill	Mokelumne River
San Pablo	East Bay MUD	Mokelumne River
Walnut Creek	East Bay MUD	Mokelumne River
	Co. Co. Co. Wat. Dist.	Co. Co. Co. Wat. Dist.
Marin County		
Belvedere	Mar. Mun. Wat. Dist.	Surface
Corte Madera	Mar. Mun. Wat. Dist.	Surface
Fairfax	Mar. Mun. Wat. Dist.	Surface
Larkspur	Mar. Mun. Wat. Dist.	Surface
Mill Valley	Mar. Mun. Wat. Dist.	Surface
Novato	No. Mar. Co. Wat. Dist.	Surface
		Russian River
Ross	Mar. Mun. Wat. Dist.	Surface
San Anselmo	Mar. Mun. Wat. Dist.	Surface
San Rafael	Mar. Mun. Wat. Dist.	Surface
Sausalito	Mar. Mun. Wat. Dist.	Surface
Tiburon	Mar. Mun. Wat. Dist.	Surface
Napa County		
Calistoga	City of Calistoga	Napa River
Napa	City of Napa	Surface
St. Helena	City of St. Helena	Surface
Yountville	City of Yountville	Surface
San Francisco County		
San Francisco	City of San Francisco	San Francisco
San Mateo County		
Atherton	Cal. Wat. Serv.	
Belmont	Belmont Co. Wat. Dist.	San Francisco
Brisbane	City of Brisbane	San Francisco
Burlingame	City of Burlingame	San Francisco
Colma	Ca. Wat. Serv.	San Francisco

COMMUNITY	MUNICIPAL WATER	
	DISTRIBUTED BY	SUPPLIED BY
Daly City	City of Daly City	San Francisco
		Wells
Half Moon Bay	Coastside Co. Wat. Dist.	San Francisco
		Wells
Hillsborough	Town of Hillsborough	San Francisco
Menlo Park	City of Menlo Park	San Francisco
	Cal. Wat. Serv.	
Millbrae	City of Millbrae	San Francisco
Pacifica	No. Coast Co. Wat. Dist.	San Francisco
Portola Valley	Cal. Wat. Serv.	San Francisco
		Surface
Redwood City	City of Redwood City	San Francisco
San Bruno	City of San Bruno	San Francisco
		Wells
San Carlos	Cal. Wat. Serv.	San Francisco
San Mateo	Cal. Wat. Serv.	San Francisco
South San Francisco	Cal. Wat. Serv.	San Francisco
	Westborough Wat. Dist.	Wells
Woodside	Cal. Wat. Serv.	San Francisco
	Skyline Co. Wat. Dist.	Surface
Santa Clara County		
Campbell	San Jose Wat. Wks.	Wells
	Campbell Wat. Co.	Surface
		SCCFCWCD*
Cupertino	City of Cupertino	Wells
	San Jose Wat. Wks.	Surface
	Cal. Wat. Serv.	SCCFCWCD
Gilroy	City of Gilroy	Wells
Los Altos	Cal. Wat. Serv.	Wells
	No. Los. Alt. Wat. Co.	
Los Altos Hills	Cal. Wat. Serv.	Wells
	Purissima Hills Wat. Dist.	San Francisco
Los Gatos	San Jose Wat. Wks.	Wells
Milpitas	City of Milpitas	San Francisco
Monte Sereno	San Jose Wat. Wks.	Wells
Morgan Hill	City of Morgan Hill	Wells
Mountain View	City of Mt. View	San Francisco
		Wells
Palo Alto	City of Palo Alto	San Francisco
San Jose	San Jose Wat. Wks.	Wells
	City of San Jose	Surface
		SCCFCWCD

COMMUNITY	MUNICIPAL WATER	
	DISTRIBUTED BY	SUPPLIED BY
Santa Clara	City of Santa Clara	Wells SCCFCWCD
Saratoga		
Sunnyvale	City of Sunnyvale Cal. Wat. Serv.	Wells San Francisco SCCFCWCD
Solano County		
Benicia	City of Benicia	Surface
Dixon	Cal. Wat. Serv.	Sol. Co. Fl. Con. WCD*
Fairfield	City of Fairfield	Sol. Co. Fl. Con. WCD
Rio Vista	City of Rio Vista	Wells
Suisun City	City of Suisun City	So. Co. Fl. Con. WCD
Vacaville	City of Vacaville	Wells So. Co. Fl. Con.
Vallejo	City of Vallejo	Cache Slough
Sonoma County		
Cloverdale	City of Cloverdale	Wells
Cotati	City of Cotati	Son. Co. Fl. Con. WCD Wells
Healdsburg	City of Healdsburg	Wells
Petaluma	City of Petaluma	Surface Wells
Rohnert Park	City of Rohnert Park	Son. Co. Fl. Con. WCD Surface
Santa Rosa	City of Santa Rosa	Son. Co. Fl. Con. WCD
Sebastopol	City of Sebastopol	Wells
Sonoma	City of Sonoma	Son. Co. Fl. Con. WCD

* Agencies which serve as suppliers of water on a wholesale basis to distributing agencies have as their supply the following sources:

San Francisco: Major source of water is surface storage in Hetch Hetchy Reservoir on the Tuolumne River in the Sierras, with secondary sources being the Alameda Creek watershed and the surface runoff into San Andreas and Crystal Springs reservoirs in San Mateo counties.

Alameda Flood Control and Water Conservation District: This agency, through its Zone 7, wholesales California Water Plan water carried in the South Bay Aqueduct.

Contra Costa County Water District: This agency, in addition to distributing water through its Treated Water Division, wholesales Bureau of Reclamation water transported by the Contra

Costa Canal.

Santa Clara County Flood Control and Water Conservation District: This agency wholesales California Water Plan water carried in the South Bay Aqueduct.

Solano County Flood Control and Water Conservation District: This agency delivers water, purchased from the Bureau of Reclamation, through the Putah South Canal.

City of Vallejo: This City sells some water as needed from its Cache Slough carrier of Bureau of Reclamation water.

Sonoma County Flood Control and Water Conservation District: This agency transports water from Russian River sources and wholesales to communities in the County.

TABLE 2

UTILITIES FURNISHING SEWERAGE SERVICE TO COMMUNITIES.

(Water, Sewerage, Drainage Survey, Association of Bay Area Governments - Sept. 1969)

COMMUNITY	SANITARY SEWAGE	
	COLLECTED BY	TREATED BY
Alameda County		
Alameda	City of Alameda	East Bay MUD
Albany	City of Albany	East Bay MUD
Berkeley	City of Berkeley	East Bay MUD
Emeryville	City of Emeryville	East Bay MUD
Fremont	Union San. Dist.	Union San. Dist.
Hayward	City of Hayward	City of Hayward
Livermore	City of Livermore	City of Livermore
Newark	Union San. Dist.	Union San. Dist.
Oakland	City of Oakland	East Bay MUD
Piedmont	City of Piedmont	East Bay MUD
Pleasanton	City of Pleasanton	City of Pleasanton
		Val. Comm. Serv.
San Leandro	City of San Leandro	City of San Leandro
	Oro Loma San. Dist.	Oro Loma San. Dist.
Union City	Union San. Dist.	Union San. Dist.
Contra Costa County		
Antioch	City of Antioch	City of Antioch
Brentwood	City of Brentwood	City of Brentwood
Clayton	City of Concord	City of Concord
El Cerrito	Stege San. Dist.	East Bay MUD
Hercules	Town of Hercules	Town of Hercules
Lafayette	Cen. Co. Co. San. Dist.	Cen. Co. Co. San. Dist.
Martinez	Mt. View San. Dist.	Mt. View San. Dist.
Pinole	City of Pinole	City of Pinole
Pittsburg	City of Pittsburg	City of Pittsburg
Pleasant Hill	Cen. Co. Co. San. Dist.	Den. Co. Co. San. Dist.
San Pablo	San Pablo San. Dist.	San Pablo San. Dist.
Walnut Creek	Cen. Co. Co. San. Dist.	Cen. Co. Co. San. Dist.

COMMUNITY	SANITARY SEWAGE	
	COLLECTED BY	TREATED BY
Marin County		
Belvedere	City of Belvedere	City of Belvedere
Corte Madera	City of Corte Madera	Ross San. Dist. (No. 1)
Fairfax	Ross San. Dist.	Ross San. Dist.
Larkspur	Larkspur San. Dist. Ross San. Dist. City of Corte Madera	Ross San. Dist.
Mill Valley	City of Mill Valley	City of Mill Valley
Novato	Novato San. Dist. (No. 6)	Novato San. Dist.
Ross	Ross San. Dist.	Ross San. Dist.
San Anselmo	Ross San. Dist.	Ross San. Dist.
Sausalito	Saus-Mar. City San. Dist.	City of Sausalito
Tiburon	San. Dist. No. 5 Rich. Bay San. Dist.	San. Dist. No. 5 Rich. Bay San. Dist.
Napa County		
Calistoga	City of Calistoga	City of Calistoga
Napa	Napa San. Dist.	Napa San. Dist.
St. Helena	City of St. Helena	City of St. Helena
Yountville	City of Yountville	City of Yountville
San Francisco County		
San Francisco	City of San Francisco	City of San Francisco
San Mateo County		
Atherton	Menlo Pk. San. Dist.	Menlo Pk. San. Dist.
Belmont	City of Belmont	Belmont-San Carlos
Brisbane	City of Brisbane	Crock. Mun. Util. Dist.
Burlingame	City of Burlingame	City of Burlingame
Colma	None	
Daly City	No. S. M. Co. San. Dist.	No. S. M. Co. San Dist.
Half Moon Bay	City of Half Moon Bay	City of Half Moon Bay
Hillsborough	Town of Hillsborough	San Mateo San. Dist. City of Burlingame
Menlo Park	Menlo Pk. San. Dist.	Menlo Pk. San. Dist.
Millbrae	City of Millbrae	City of Millbrae
Pacifica	City of Pacifica	City of Pacifica

COMMUNITY	SANITARY SEWAGE	
	COLLECTED BY	TREATED BY
Portola Valley	Menlo Pk. San. Dist. Septic Tanks	Menlo Pk. San. Dist.
Redwood City	City of Redwood City	City of Redwood City
San Bruno	City of San Bruno	San Burno-So. San Francisco
San Carlos	City of San Carlos	City of San Carlos
San Mateo	San Mateo San. Dist.	San Mateo San. Dist.
South San Francisco	City of South San Francisco Westborough Wat. Dist.	San Bruno-So. San Francisco No. San Mateo Co. San. Dist
Woodside	Fairoaks San. Dist. Septic Tanks	Redwood City
Santa Clara County		
Campbell	Co. San. Dist. No. 4	San Jose
Cupertino	Cup. San. Dist.	San Jose
Gilroy	City of Gilroy	City of Gilroy
Los Altos	City of Los Altos	City of Los Altos
Los Altos Hills	Mostly Septic Tanks	
Los Gatos	Co. San. Dist. No. 4	San Jose
Milpitas	City of Milpitas	City of Milpitas
Monte Sereno	San. Dist. No. 4	San Jose
Morgan Hill	City of Morgan Hill	Gilroy
Mountain View	City of Mt. View	City of Mt. View
Palo Alto	City of Palo Alto	City of Palo Alto
San Jose	City of San Jose	San Jose-Santa Clara
Santa Clara	City of Santa Clara	San Jose-Santa Clara
Saratoga	Co. San. Dist. No. 4	San Jose
Sunnyvale	City of Sunnyvale	City of Sunnyvale
Solano County		
Benicia	City of Benicia	City of Benicia
Dixon	City of Dixon	City of Dixon
Fairfield	Fairfield-Suisun San. Dist.	Fairfield-Suisun San. Dist.
Rio Vista	City of Rio Vista	City of Rio Vista
Suisun City	Fairfield-Suisun San. Dist.	Fairfield-Suisun San. Dist.
Vacaville	City of Vacaville	City of Vacaville
Vallejo	Vallejo San.& F.I.C. Dist.	Vallejo San.& F.I.C.
Sonoma County		
Cloverdale	City of Cloverdale	City of Cloverdale
Cotati	City of Cotati	City of Cotati

COMMUNITY	SANITARY SEWAGE	
	COLLECTED BY	TREATED BY
Healdsburg	City of Healdsburg	City of Healdsburg
Petaluma	City of Petaluma	City of Petaluma
Rohnert Park	City of Rohnert Park	City of Rohnert Park
Santa Rosa	City of Santa Rosa	City of Santa Rosa
Sebastopol	City of Sebastopol	City of Sebastopol
Sonoma	Sonoma Valley County	Sonoma Valley County San. Dist.

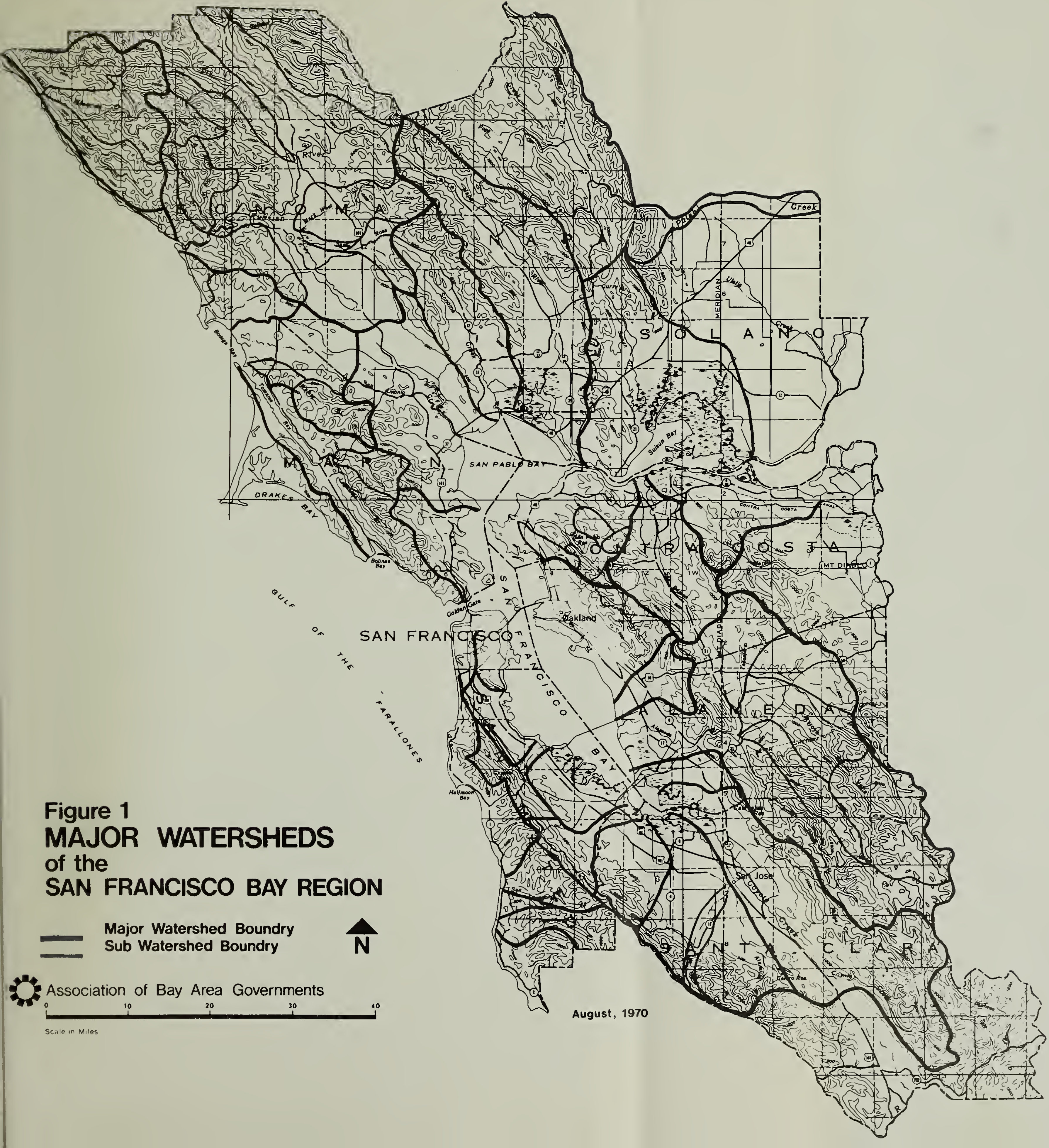


Figure 1
MAJOR WATERSHEDS
of the
SAN FRANCISCO BAY REGION

EXPERIENCE OF MORGAN JOHNSON, Ph.D.
IN THE FIELDS OF WATER RESOURCES ENGINEERING

ACADEMIC, RESEARCH AND PUBLICATIONS

B.S., M.S., and Ph.D. degrees in civil engineering.
Ground water study in graduate program.
Sixteen years of university teaching undergraduate and graduate courses, including water supply, sewerage, sanitary engineering, hydraulics, and hydrology.
Airphoto mapping of drainage basins.
Research on loads on underground conduits.
Study of ground water basins.

ASSISTANT CITY ENGINEER, PHOENIX, ARIZONA

Author of ten-year storm drainage program.
Special flood control studies.
Supervision of irrigation design in street right-of-way.
Design of combination storm and irrigation lines.
Writing and/or revising specifications for materials and construction.
Design plans for all water and sewer lines and other facilities built under jurisdiction of Public Works Department.
Park drainage and irrigation facilities.
Administrative responsibility for major treatment plant design.

INDIVIDUAL PROFESSIONAL CONSULTING AND EMPLOYMENT

Water treatment piping systems, Texas.
Project engineer on designs of large pumping plant, Michigan.
Storm and flood water designs, Michigan and Arizona.
Seepage investigations, Michigan.
Combination of flood control and recreation projects, Arizona.

Hydraulics and hydrology planning, California.
Utility phases of general plans for cities and counties, Michigan and Arizona.

HEAD OF CONSULTING ENGINEERING FIRM, MICHIGAN AND ARIZONA

Sanitary Sewage

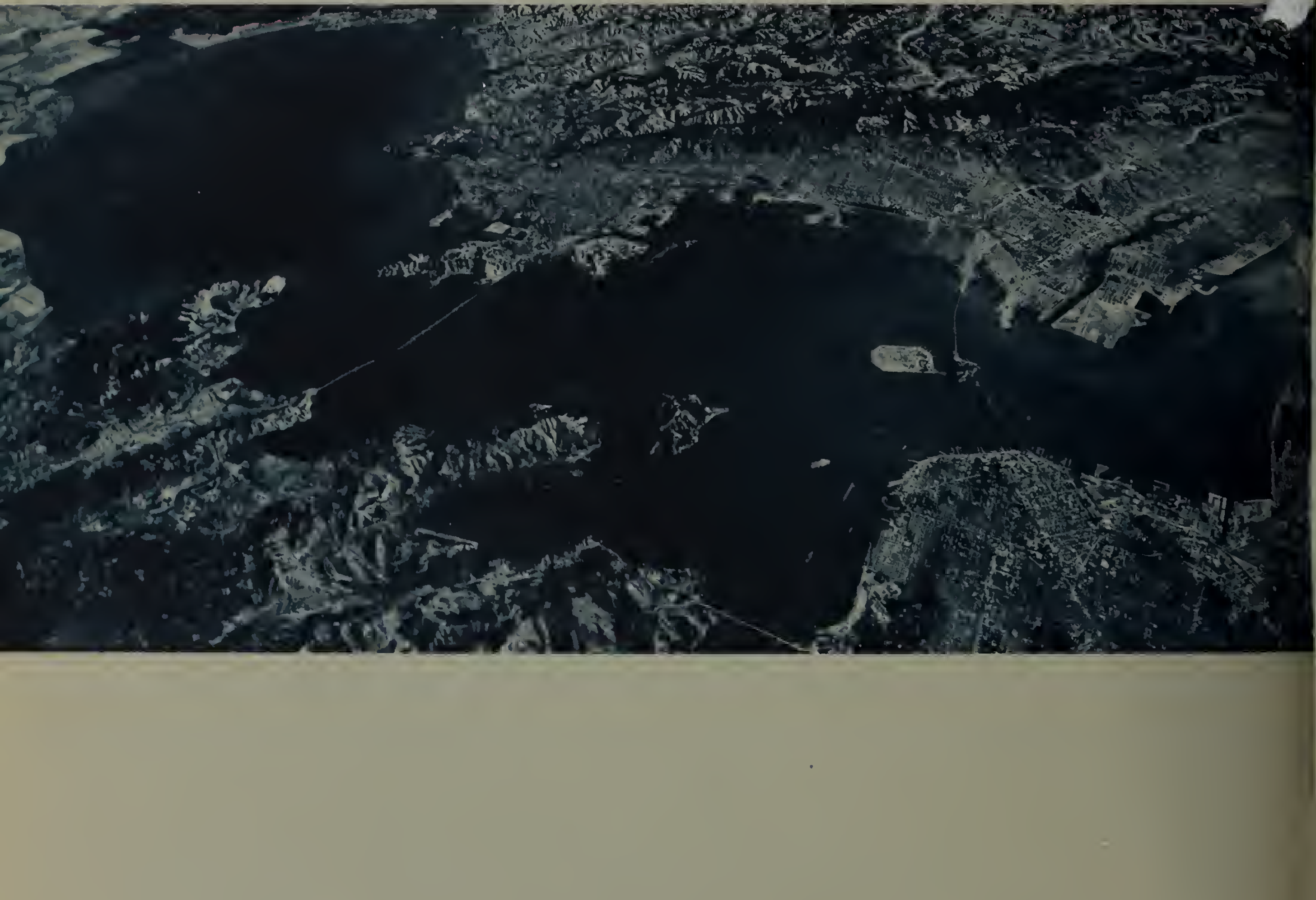
Studies of sewage needs for governmental agencies.
Consultation on formation and operation of utility companies.
Design of combined sanitary and storm sewer.
Design and construction of sanitary sewers and trunks.
Preliminary studies for sewage treatment.
Design and construction of sewage treatment plant.
Consultant on construction of treatment plants.
Design and construction of sewage pumping stations.
Modification of sewage treatment facilities.

Water Supply and Distribution

Preliminary design and studies for water supply and storage.
Consultant to public agencies on water supply problems.
Consultant to privately owned public utilities.
Design and construction of water distribution lines and trunks.
Development of water supply for new communities.
Design and construction of water treatment plant.
Consultant to regional planning commission on six-county water study. Detroit Metropolitan Area Regional Planning Commission, Detroit, Michigan.
Feasibility study for water revenue bond issue.

Storm, Flood, and Recreation

Study of municipal storm sewer needs.
Design and construction of local storm sewers.
Design and construction of storm water outfalls.
Design of storm water pumping station.
Design and construction of retention dam.
Irrigation and drainage for public parks.
Design and construction of municipal swimming pools.
Drainage studies for rural and urban areas.
Design of recreation lakes.



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ASSOCIATION OF BAY AREA GOVERNMENTS